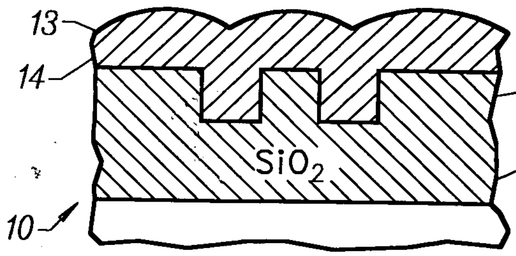


FIG. 1A

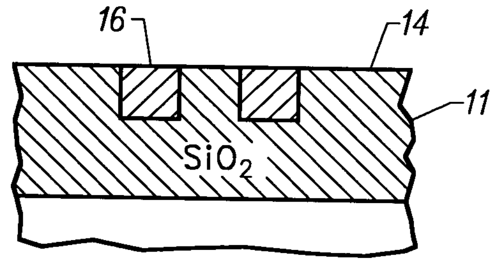


FIG. 1B

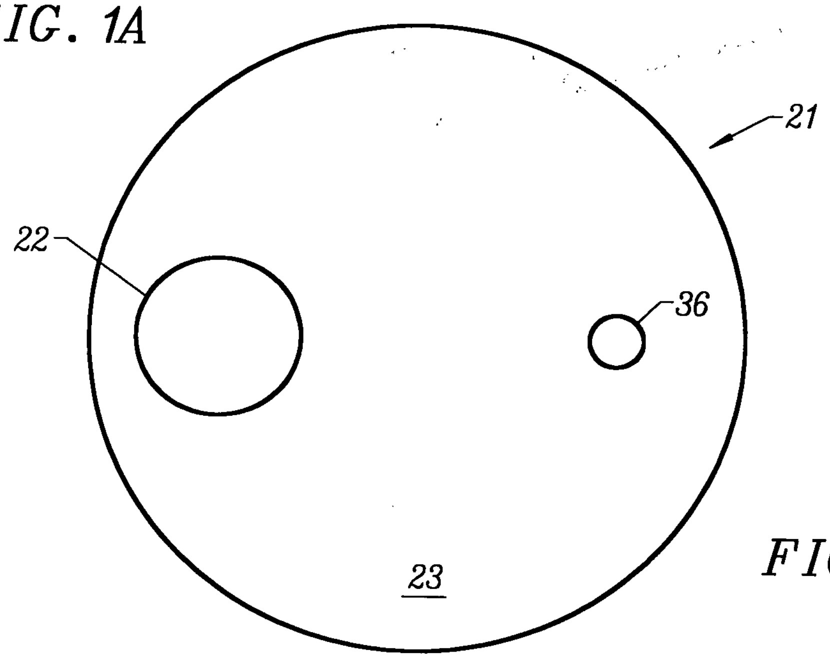


FIG. 2

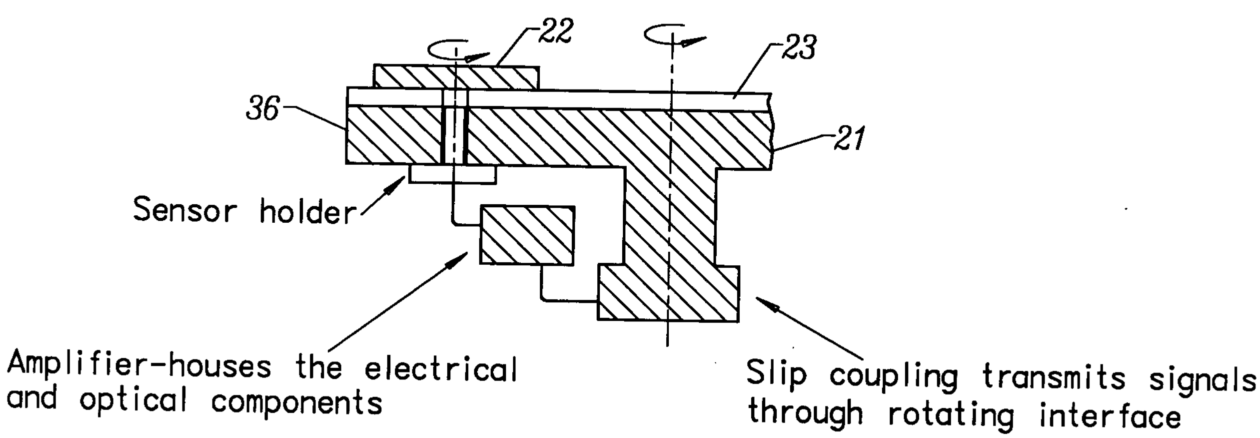


FIG. 3

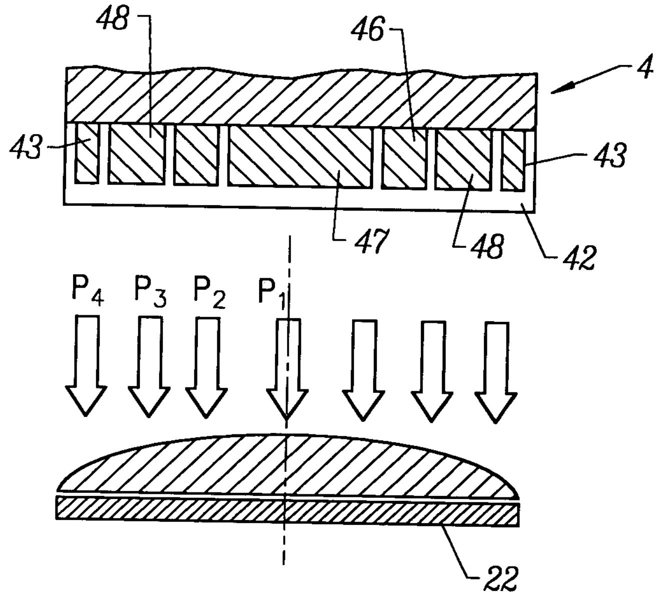


FIG. 4

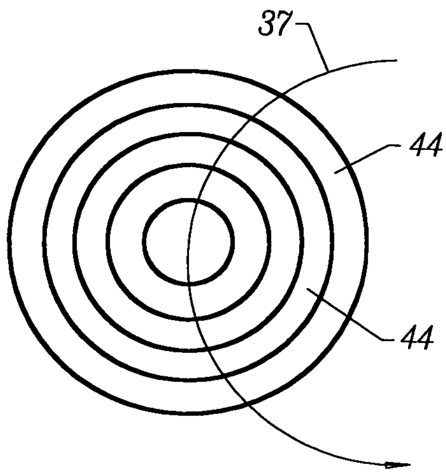


FIG. 5

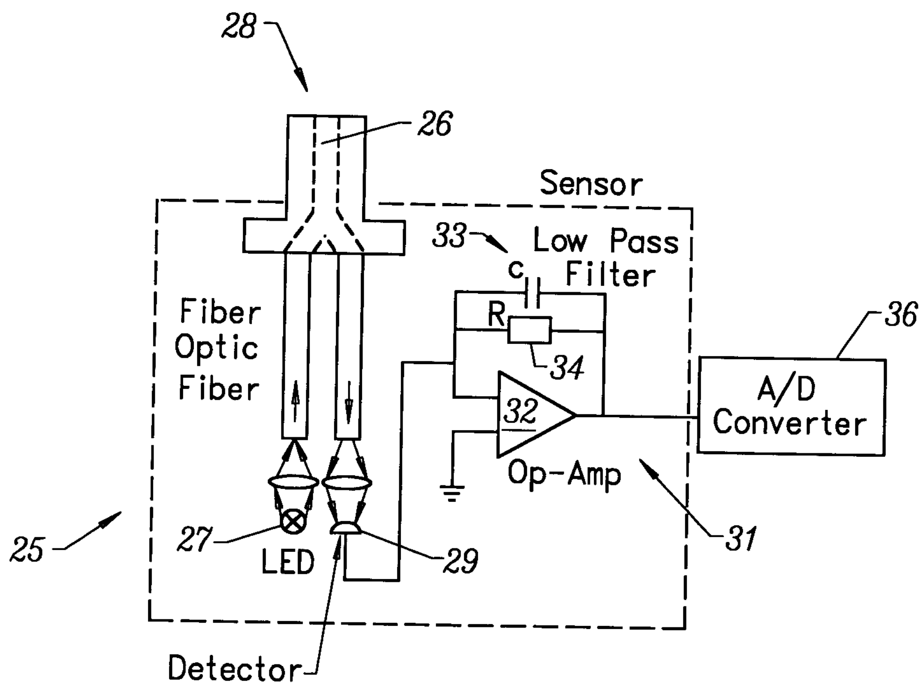


FIG. 6

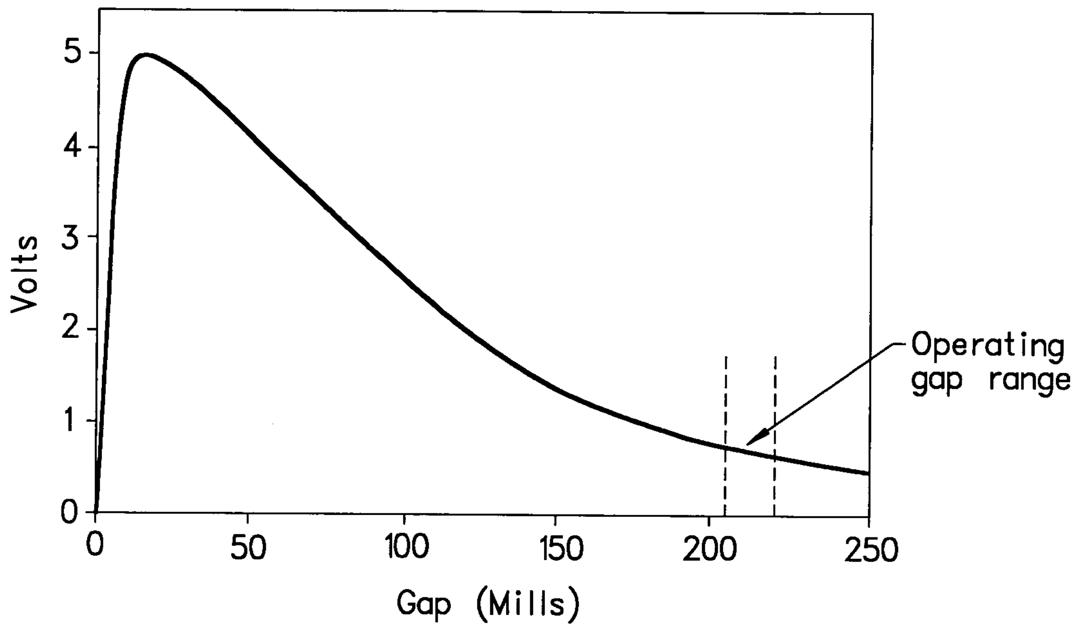


FIG. 7

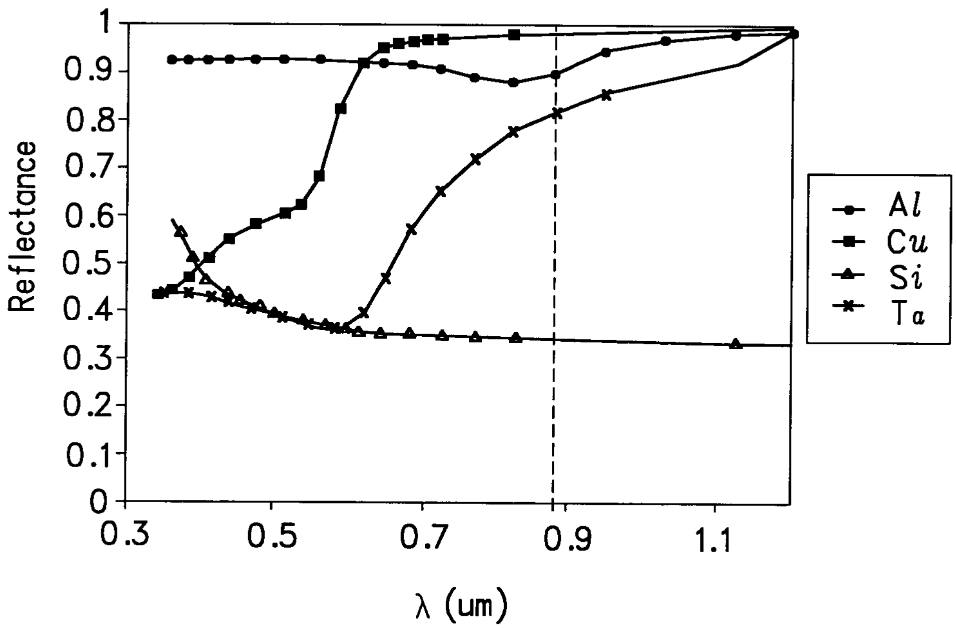


FIG. 8

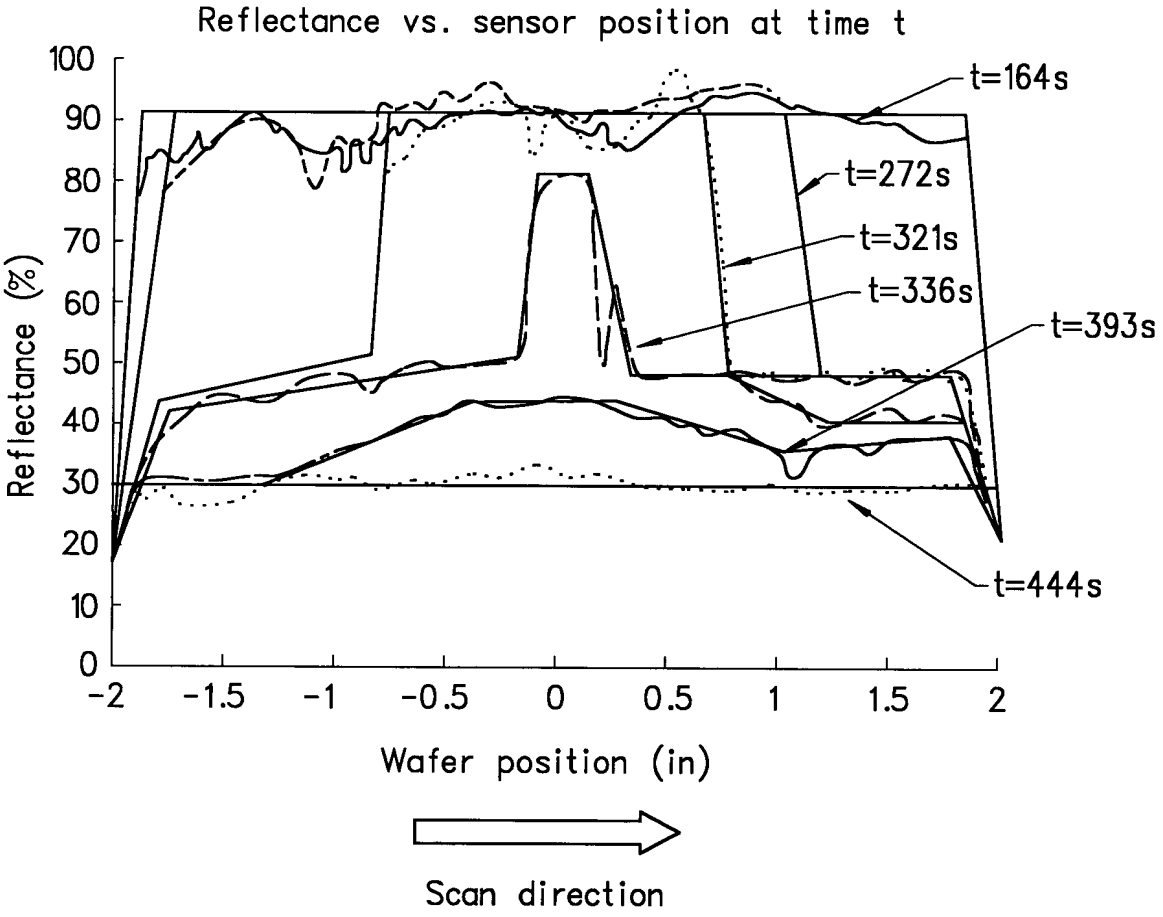

Reflectance vs. sensor position at time t
Reflectance (%)
100
90
80
70
60
50
40
30
20
10
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
Wafer position (in)
t=164s
t=272s
t=321s
t=336s
t=393s
t=444s
Scan direction

FIG. 9

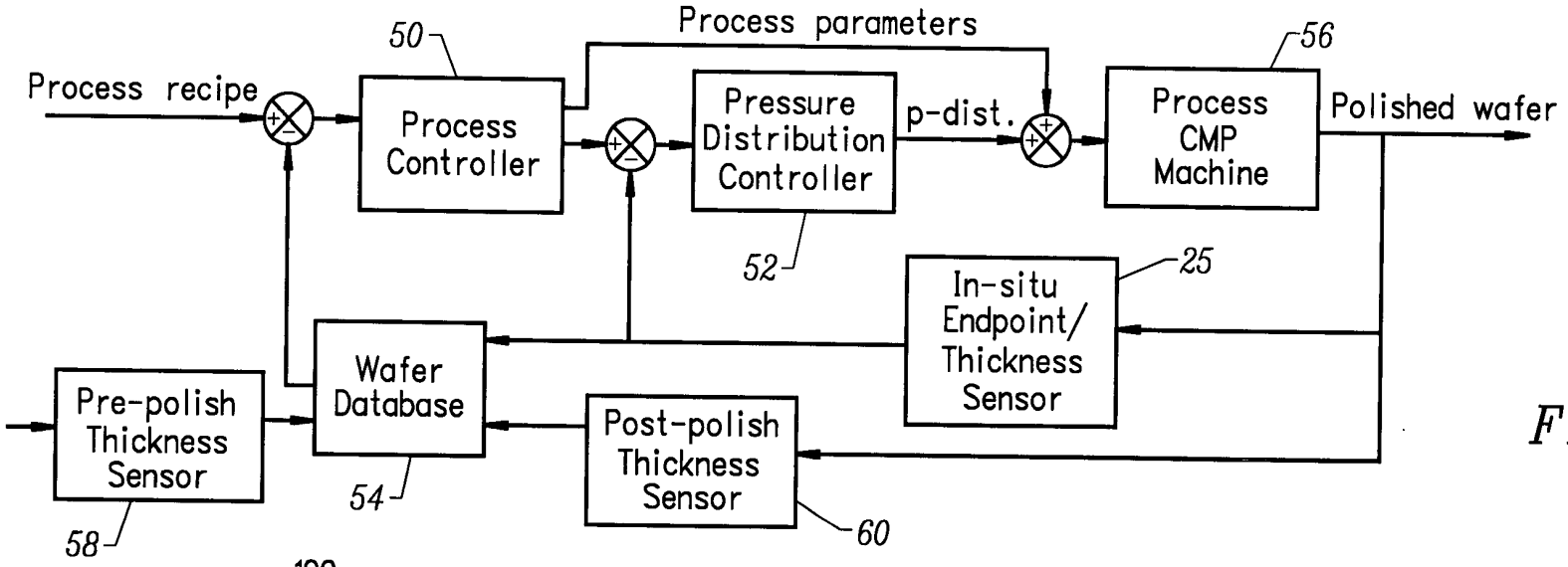


FIG. 11

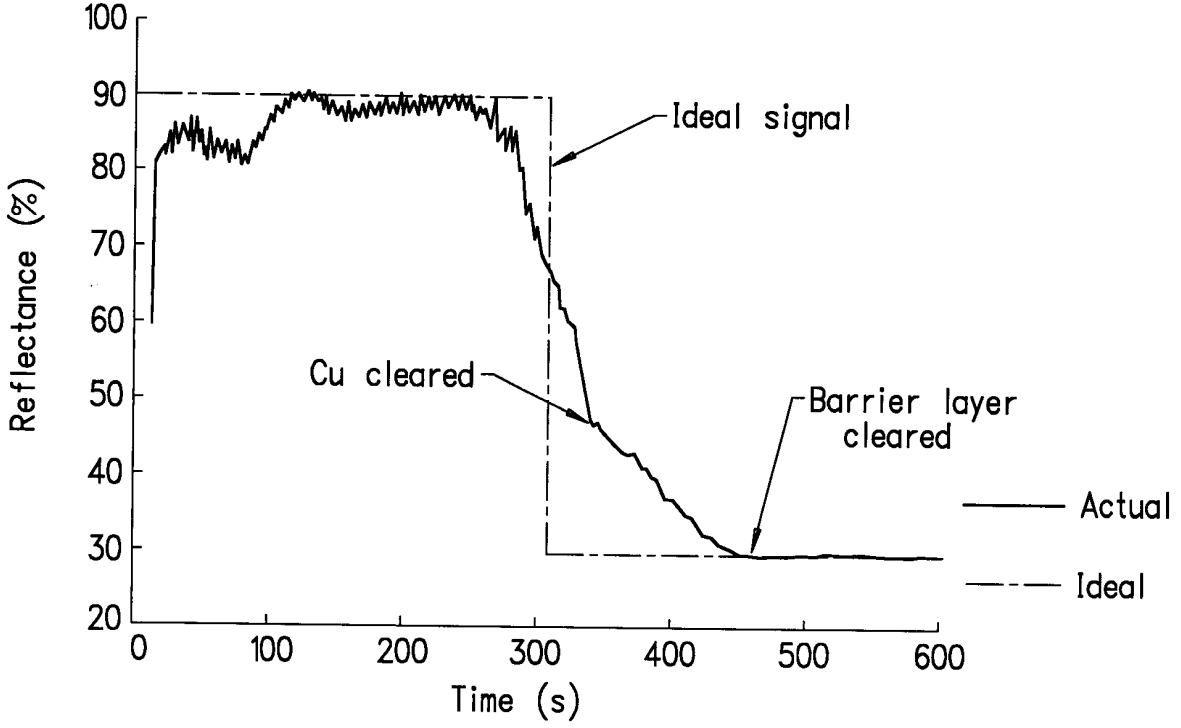


FIG. 10

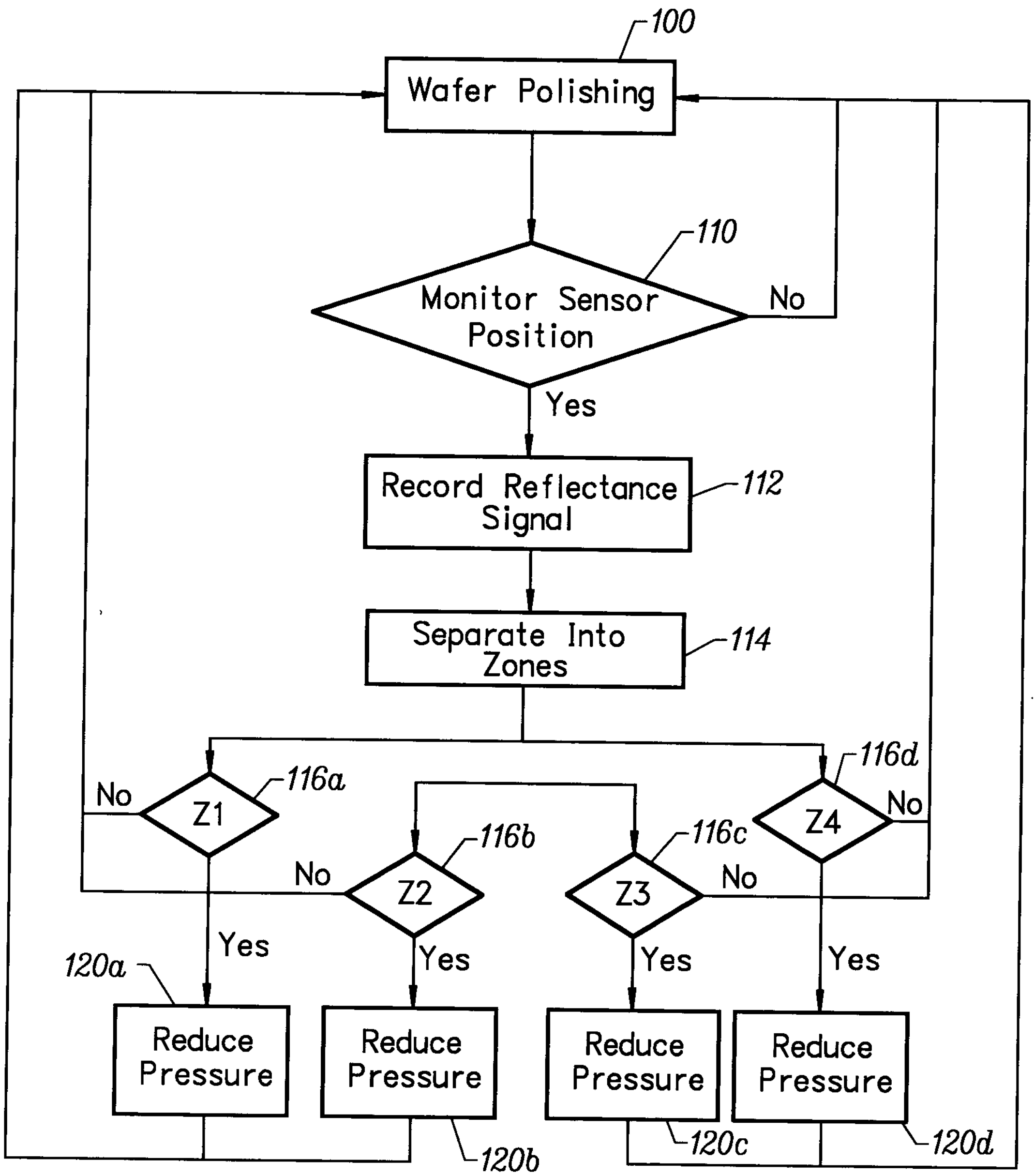


FIG. 12

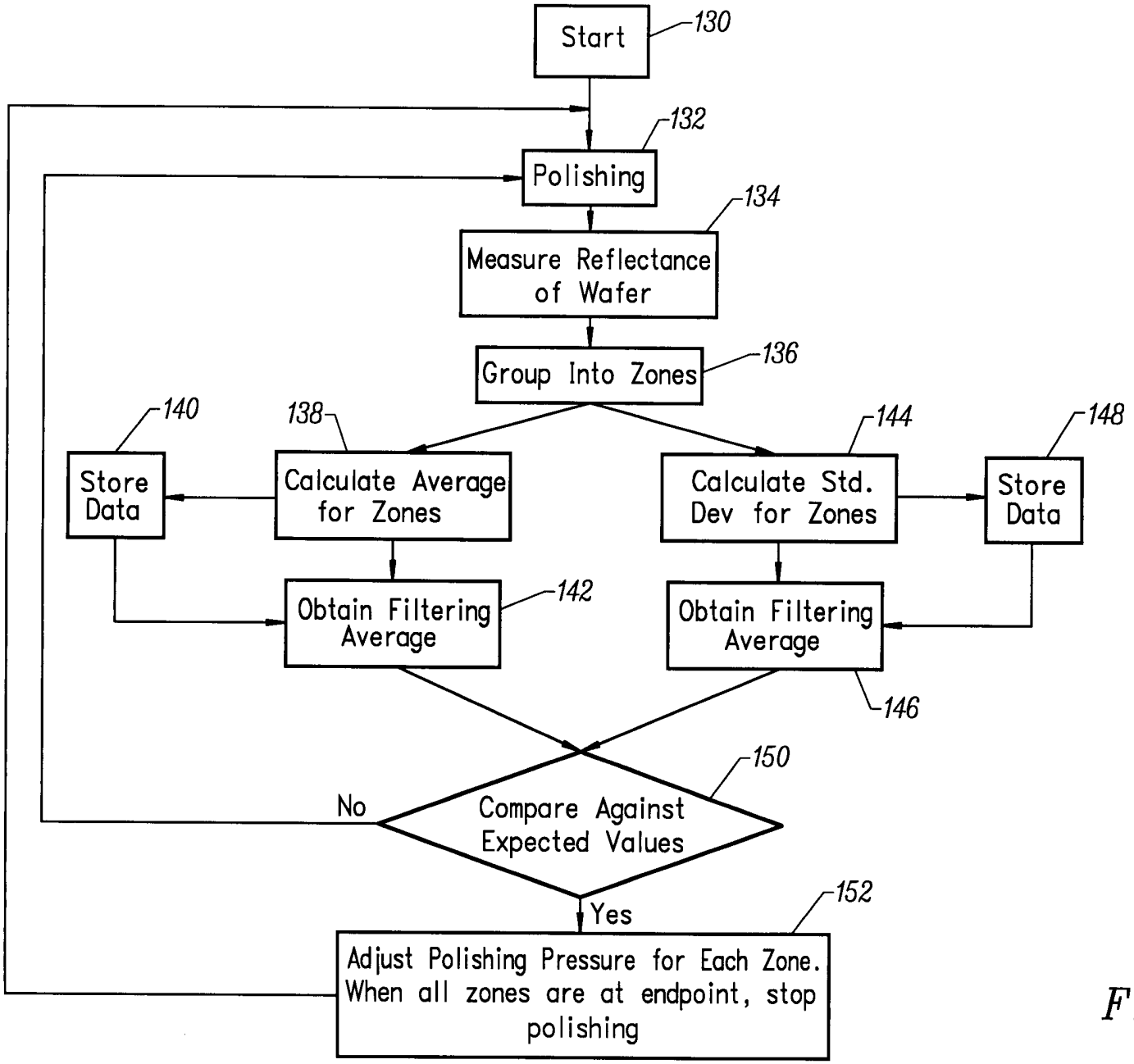
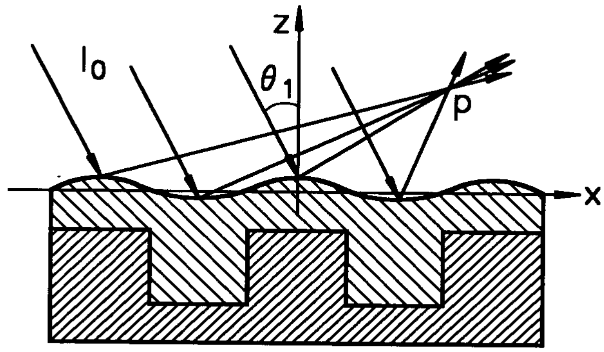
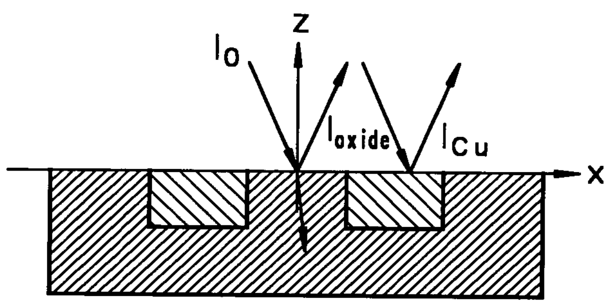

Start
130
Polishing
132
Measure Reflectance of Wafer
134
Group Into Zones
136
Store Data
140
Calculate Average for Zones
138
Calculate Std. Dev for Zones
144
Store Data
148
Obtain Filtering Average
142
Obtain Filtering Average
146
Compare Against Expected Values
150
No
Yes
Adjust Polishing Pressure for Each Zone. When all zones are at endpoint, stop polishing
152

FIG. 13



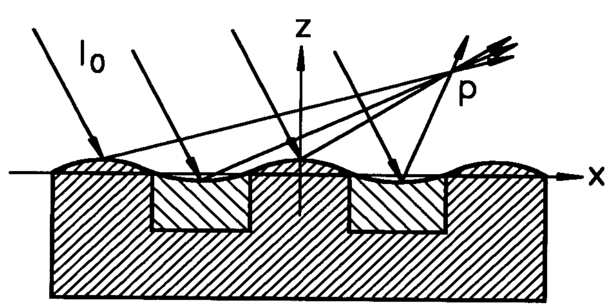
Scematics of light scattering on
a patterned Cu surface.

FIG. 14



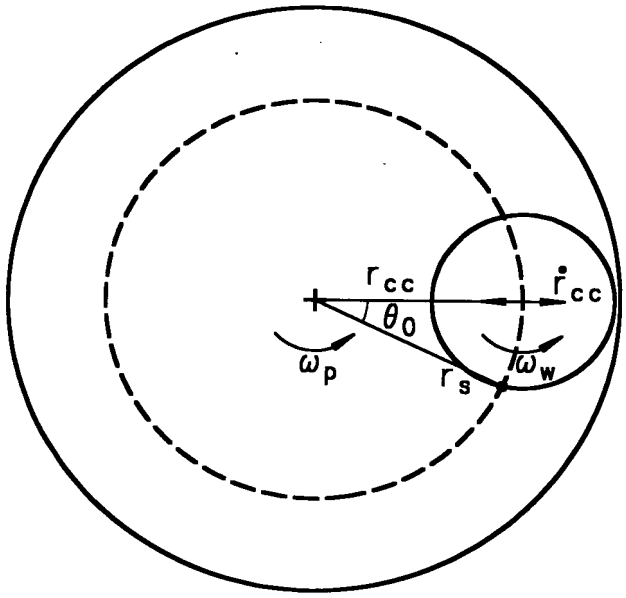
Schematics of light scattering from
a planar composite surface.

FIG. 15A



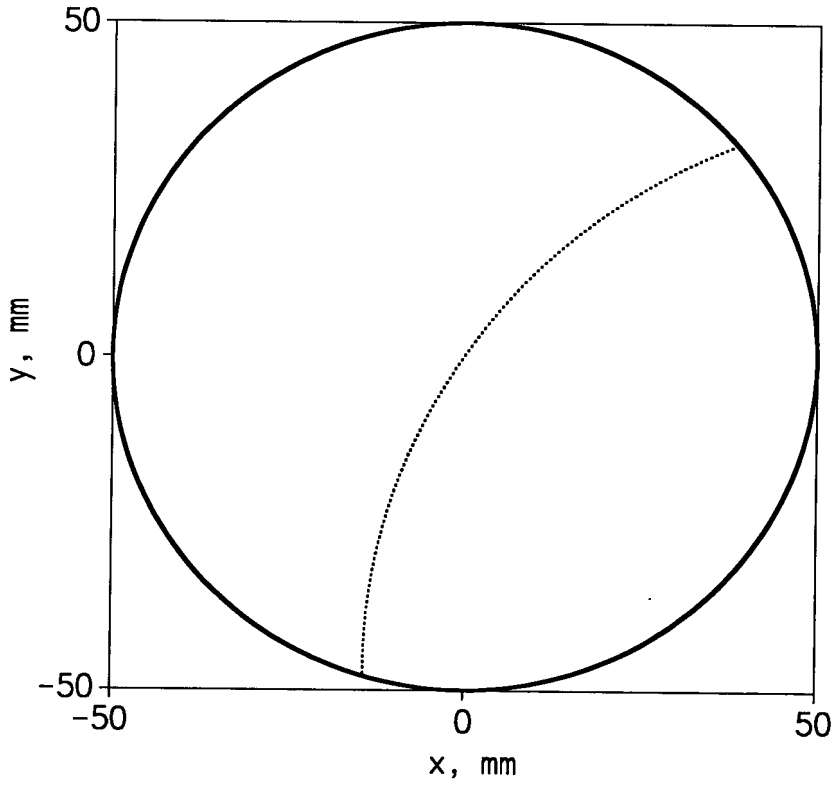
Schematics of light scattering from
a wavy composite surface.

FIG. 15B



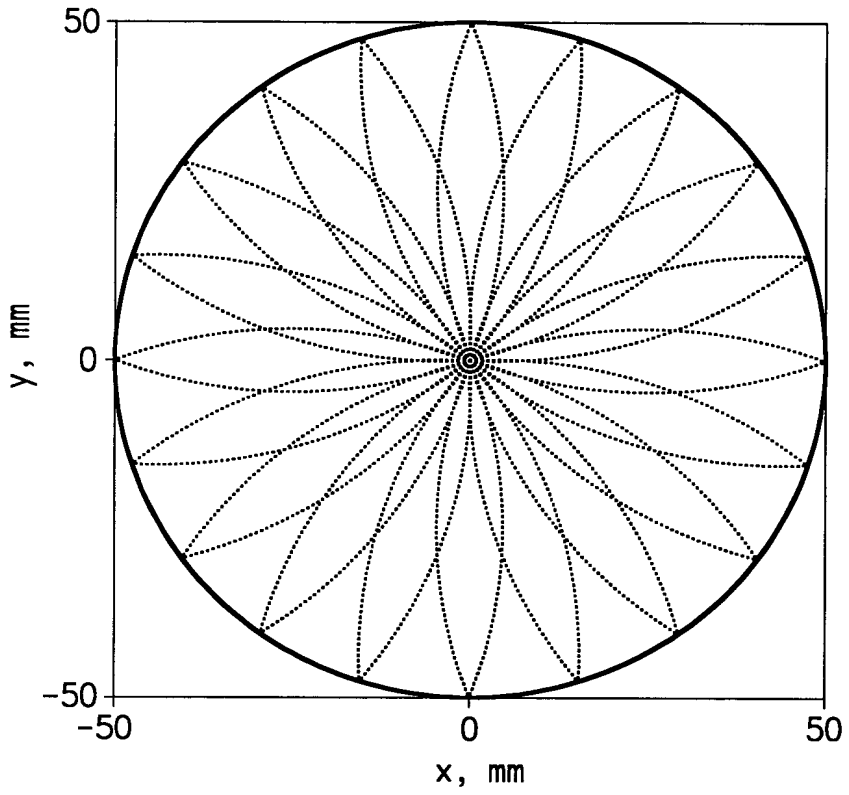
Sensor kinematics.

FIG. 16



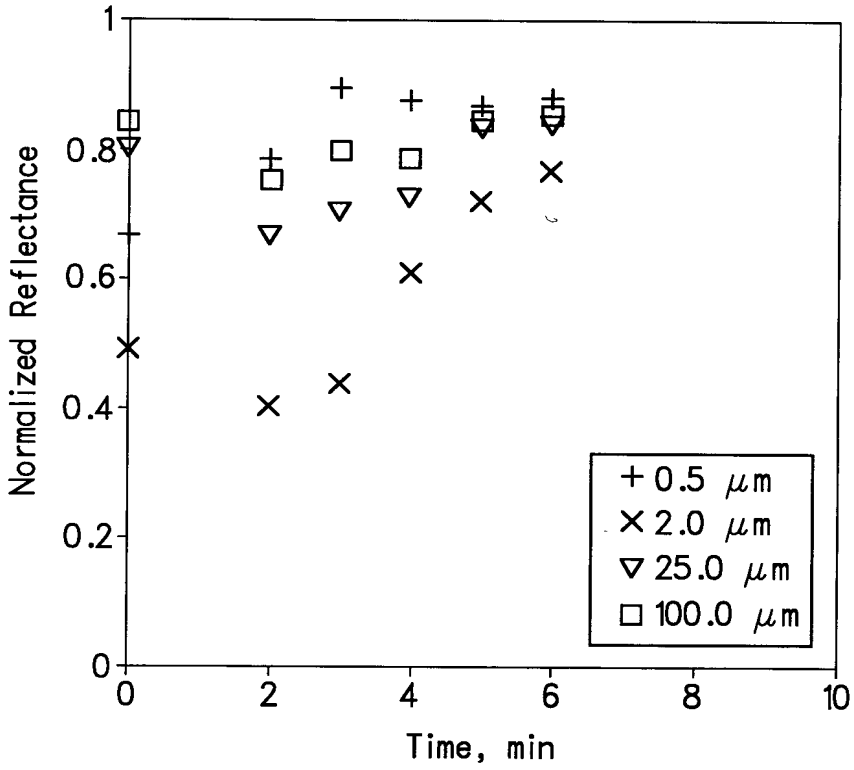
The simulated locus for the reflectance sensor across the wafer at the condition $\omega_w = \omega_p$ and $r_s = r_{cc}$.

FIG. 17



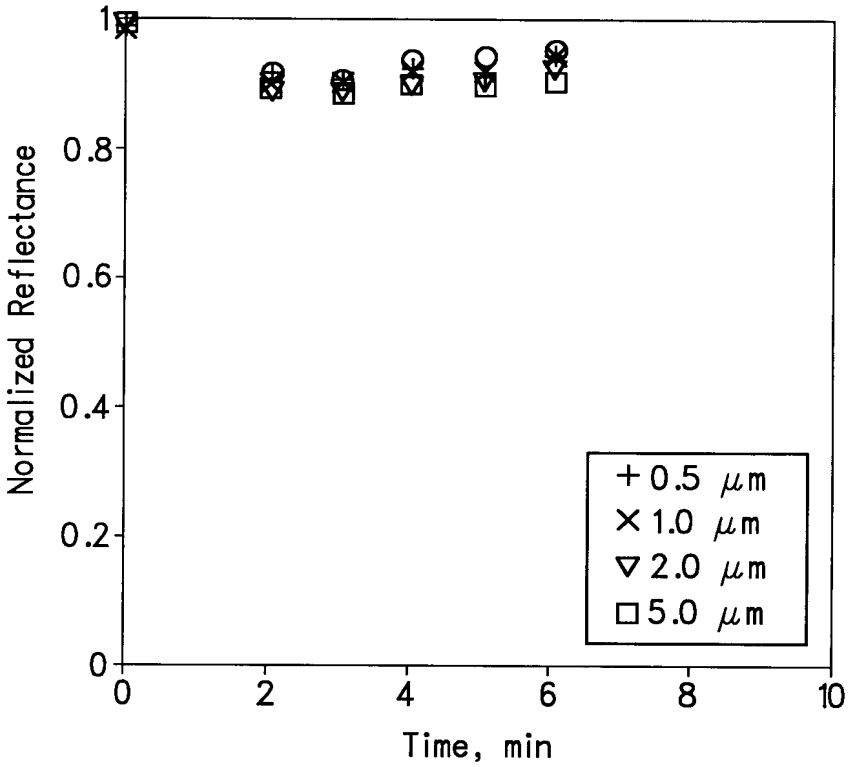
The simulated locus for the reflectance sensor across the wafer at the condition $\omega_w = 1.05\omega_p$ and $r_s = r_{cc}$.

FIG. 18



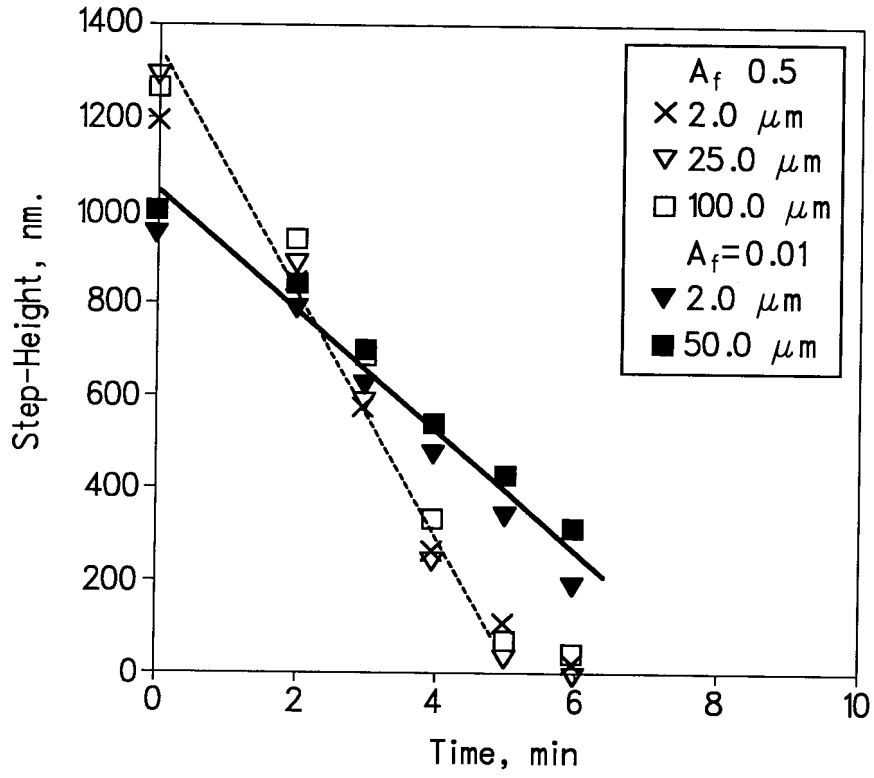
The results of off-line measurements at the Cu Planarization regimes on the pattern with 0.5 area fraction ($\omega/\lambda = 0.5$).

FIG. 19



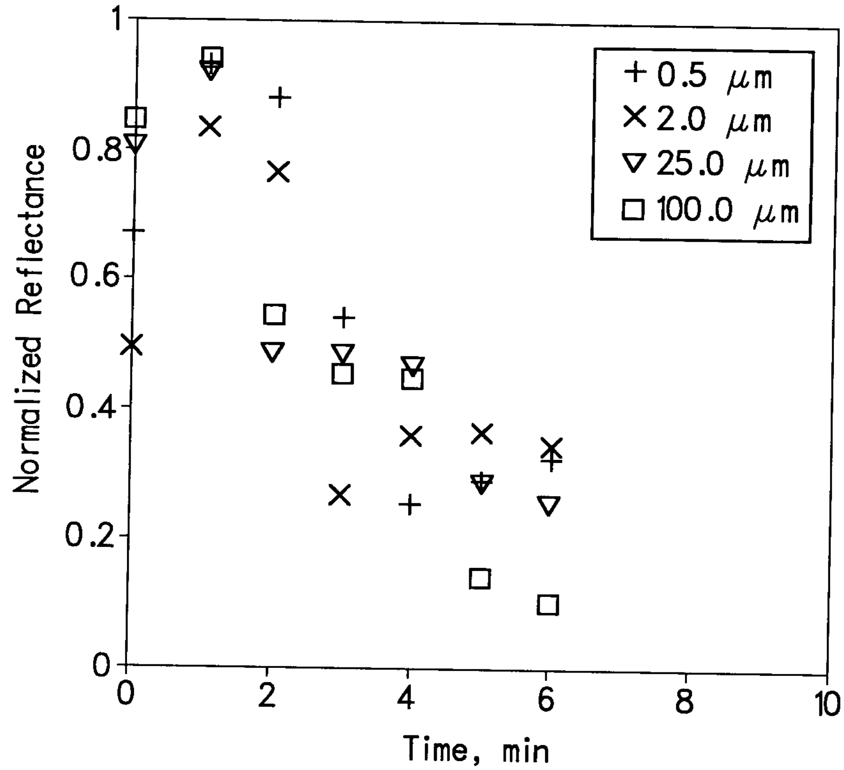
The results of off-line measurements at the Cu Planarization regimes on the patterns with 0.01 area fraction ($\omega/\lambda = 0.1$).

FIG. 20



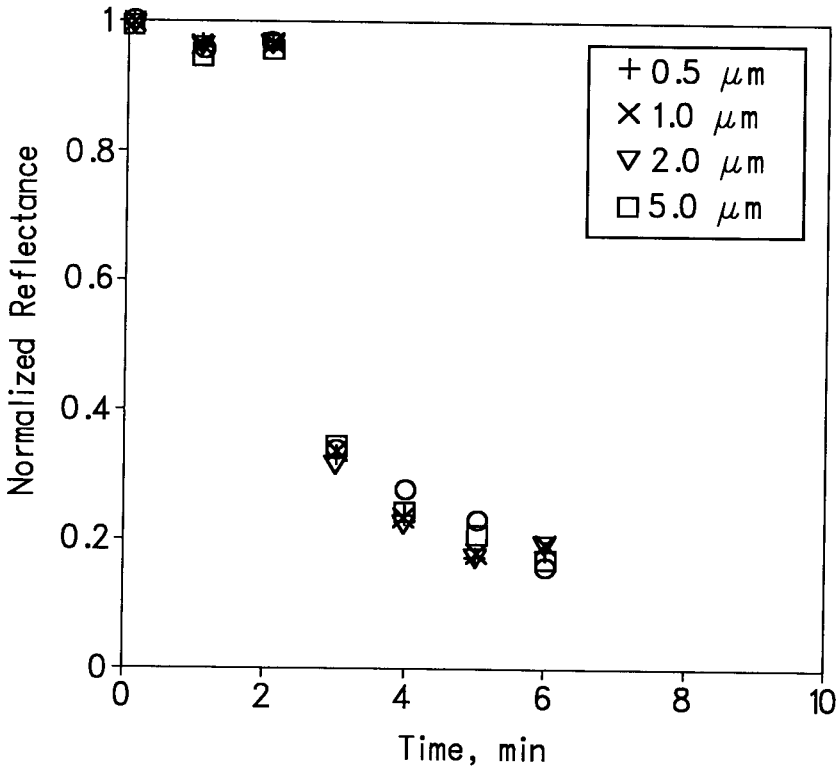
Time evolution of step-heights for patterns with constant area fraction 0.5 and 0.01.

FIG. 21



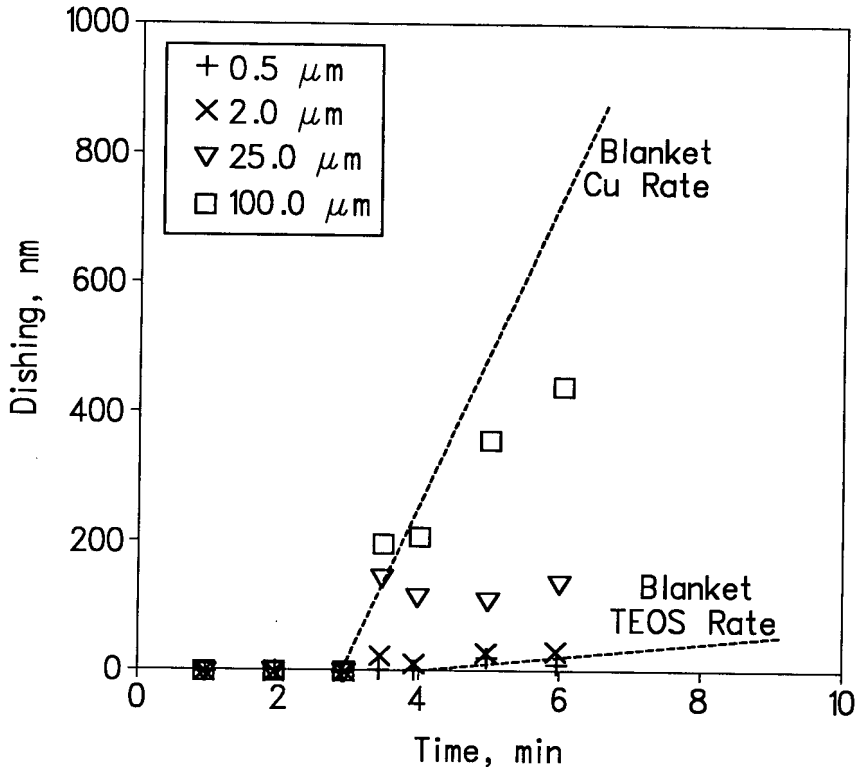
The results of off-line measurements at various process reqimes on the pattern with 0.5 area fraction.

FIG. 22



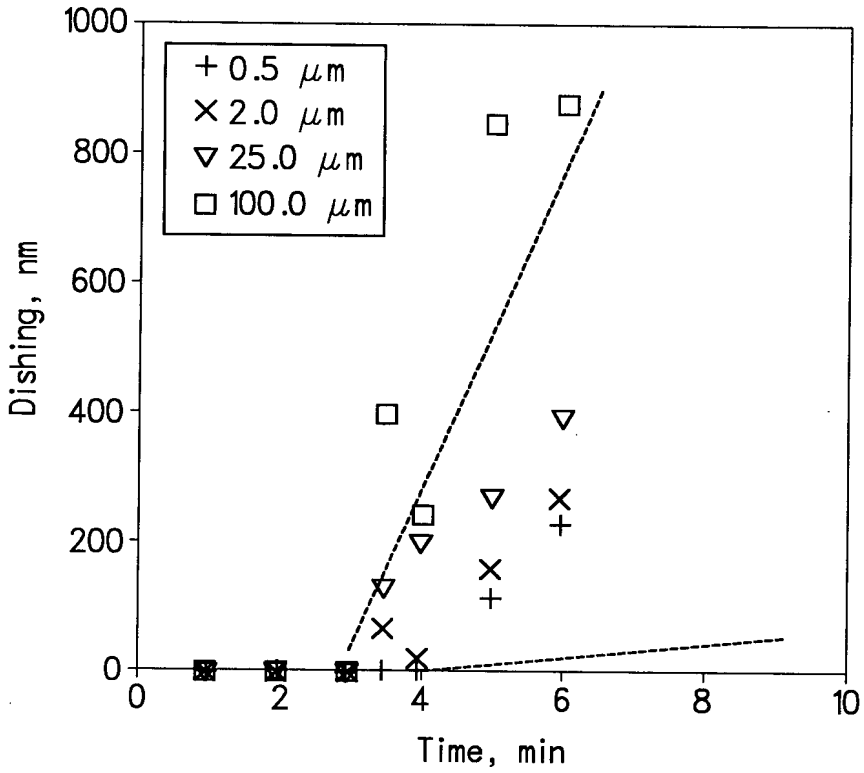
The results of off-line measurements at various process regimes on the pattern with 0.01 area fraction.

FIG. 23



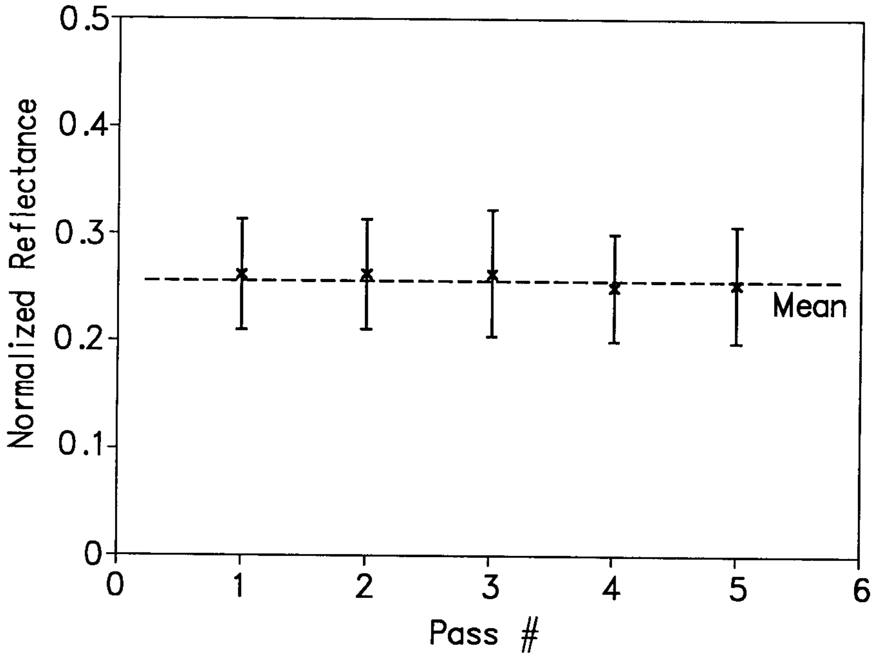
Time evolution of Cu dishing for patterns with constant area fraction 0.5 and various linewidths.

FIG. 24



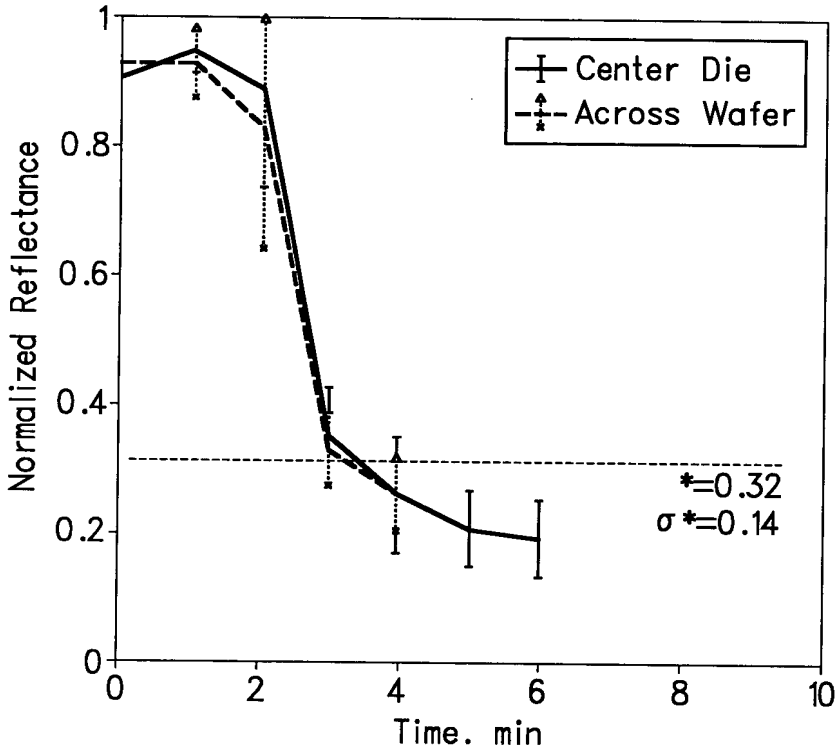
Time evolution of Cu dishing for patterns with constant area fraction 0.01 and various linewidths.

FIG. 25



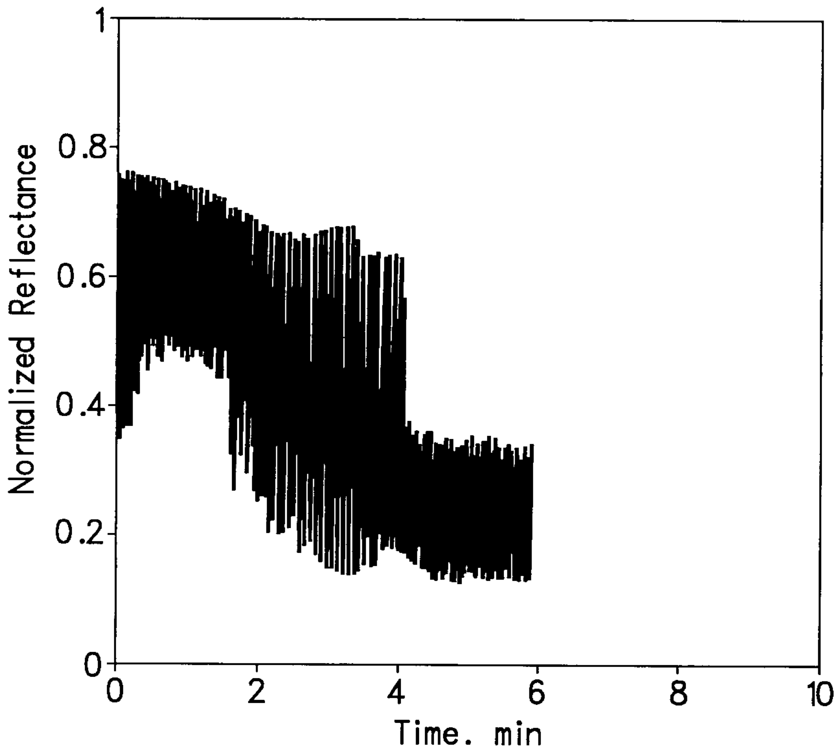
Off-line measurements of the mean and standard deviation of surface reflectance along different loci across the wafer at the onset of endpoint.

FIG. 26



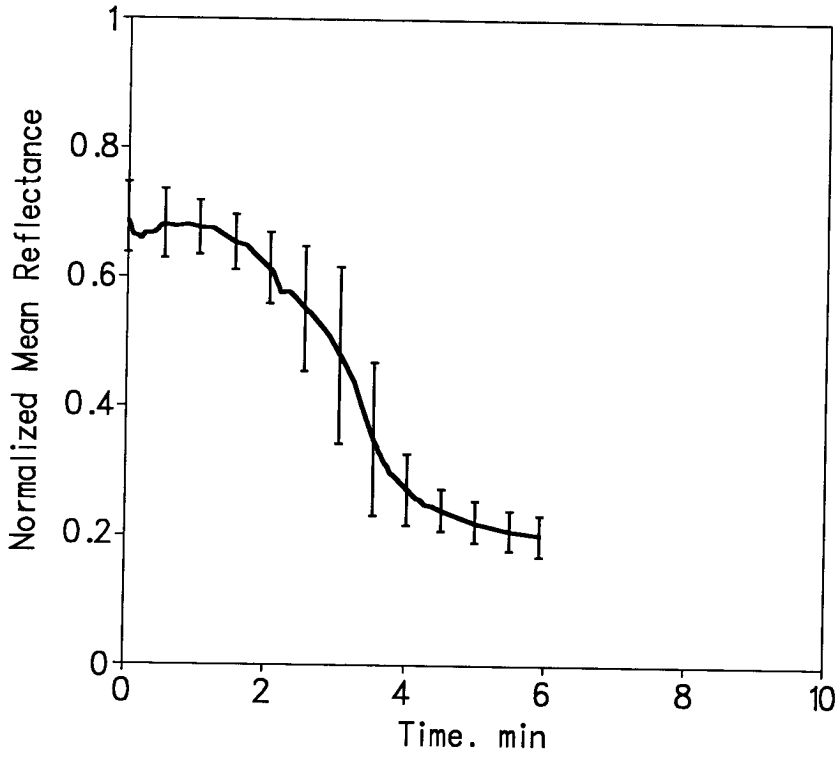
Comparison of the off-line measurements (mean and standard deviation) on the center die and across wafer at various polishing stages. The across-wafer data is calculated based on the measurements along five loci.

FIG. 27



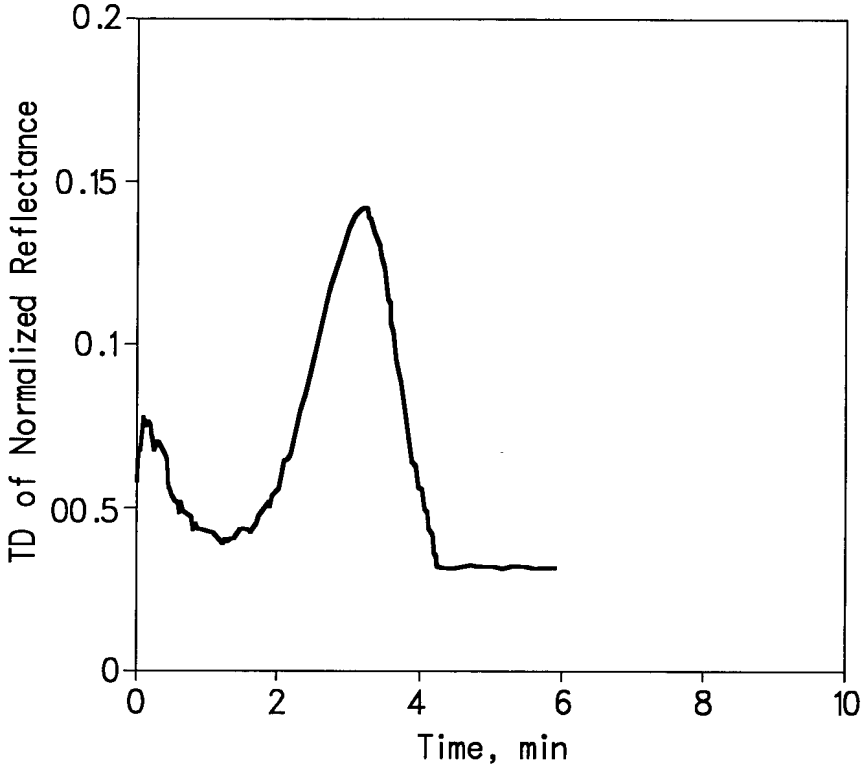
Raw data from in-situ reflectance measurement.

FIG. 28



Results of in-situ measurements of the moving average and standard deviation of wafer-level surface reflectance.

FIG. 29



Results of in-situ measurements of the standard deviation of wafer-level surface reflectance.

FIG. 30

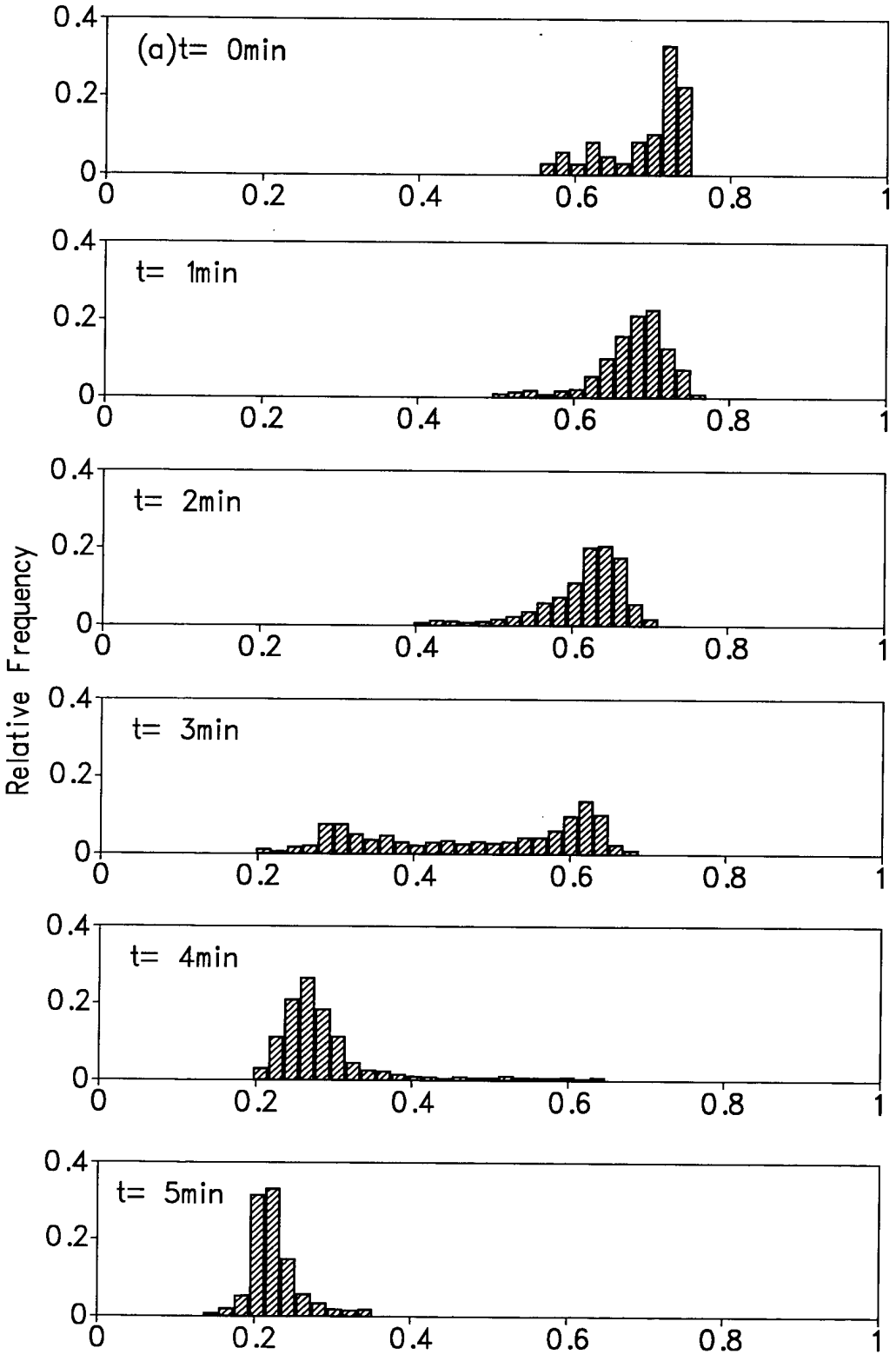


FIG. 31A

FIG. 31B

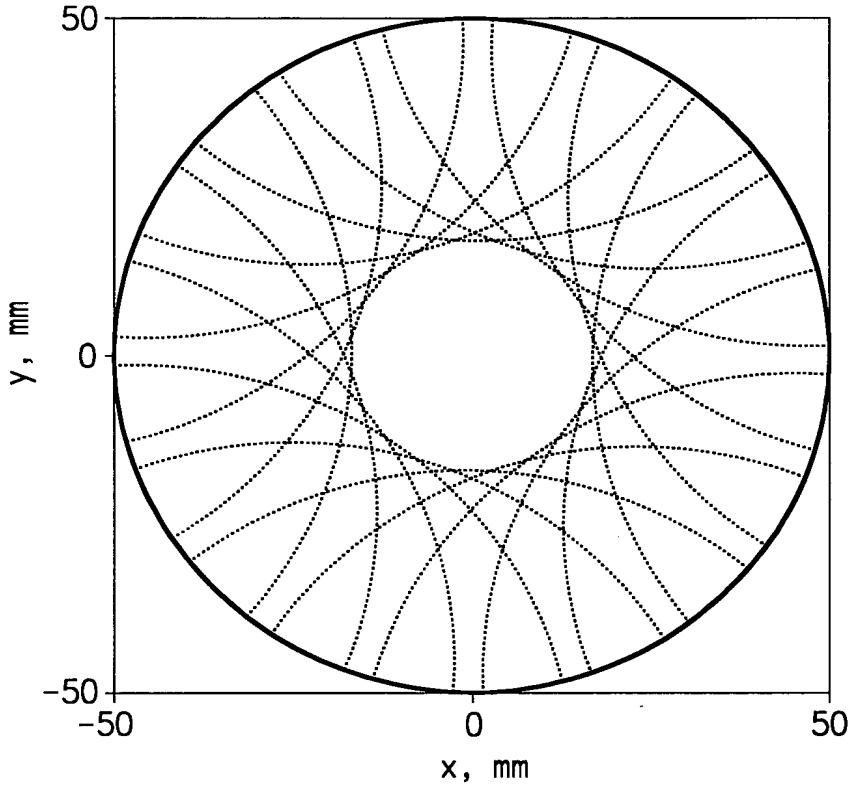
FIG. 31C

FIG. 31D

FIG. 31E

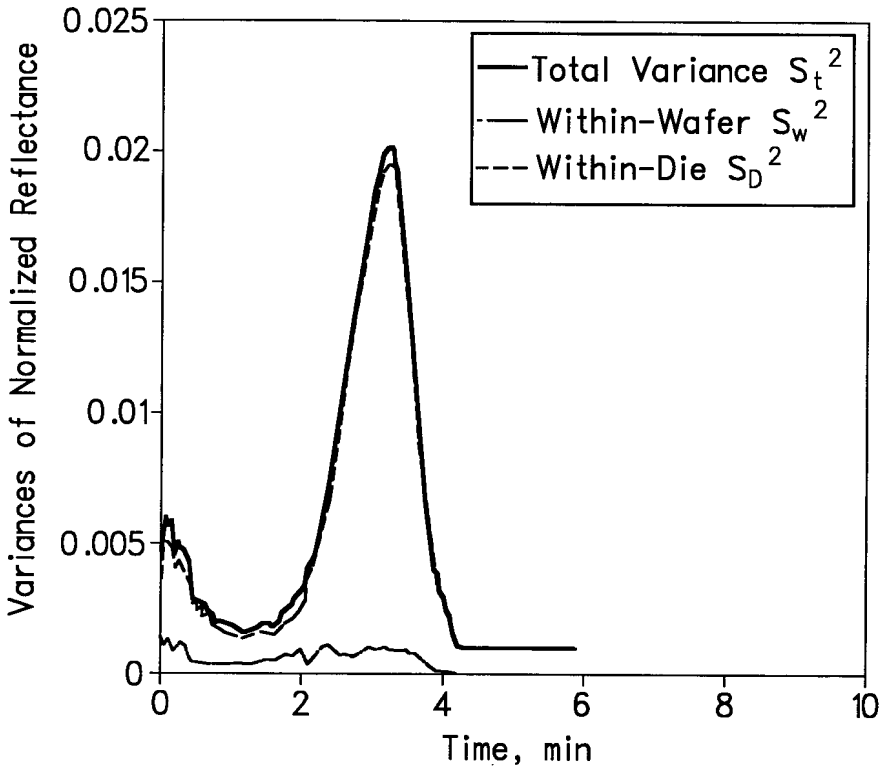
FIG. 31F

Distribution of surface reflectance versus polishing time from the in-situ measurements.



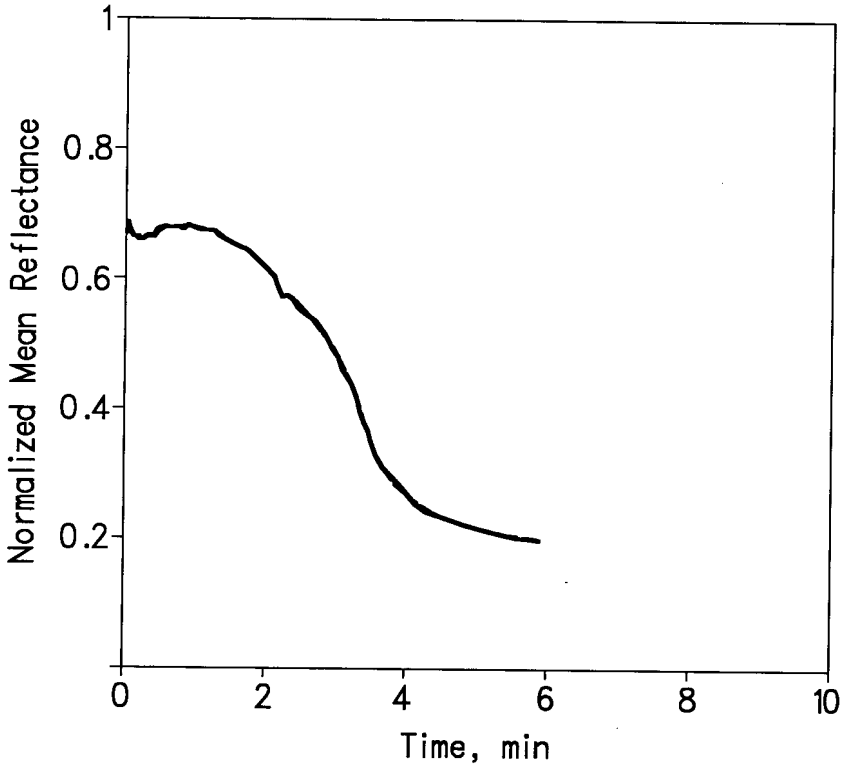
The simulated loci for the reflectance sensor across the wafer at the condition $1.05\omega_w = \omega_p$ and $r_s = 1.25r_{cc}$.

FIG. 32



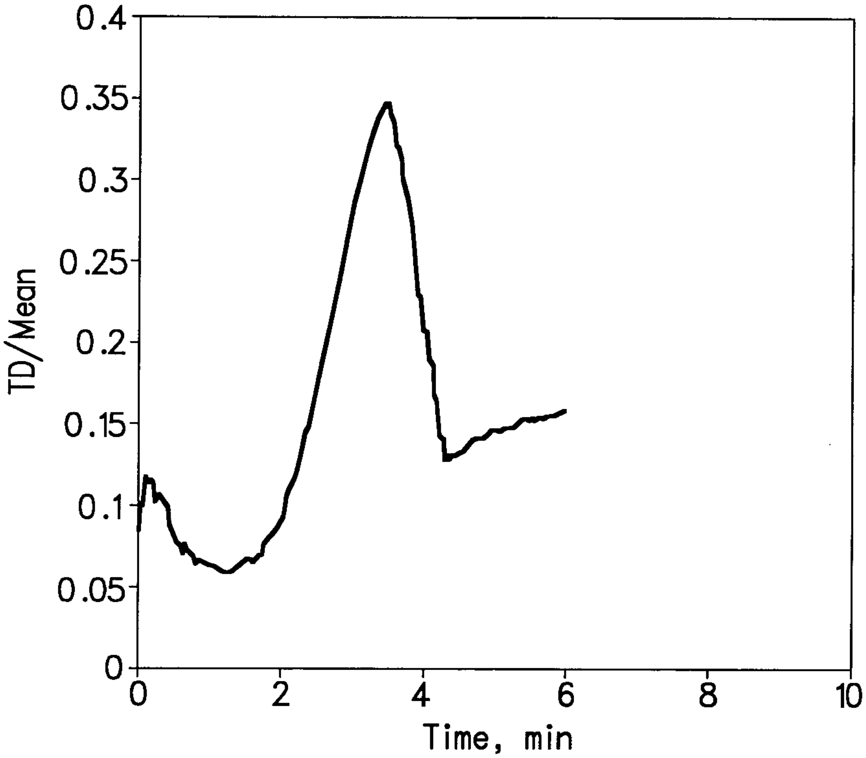
Decomposition of the within-wafer and within-die variance for the in-situ measurements.

FIG. 33



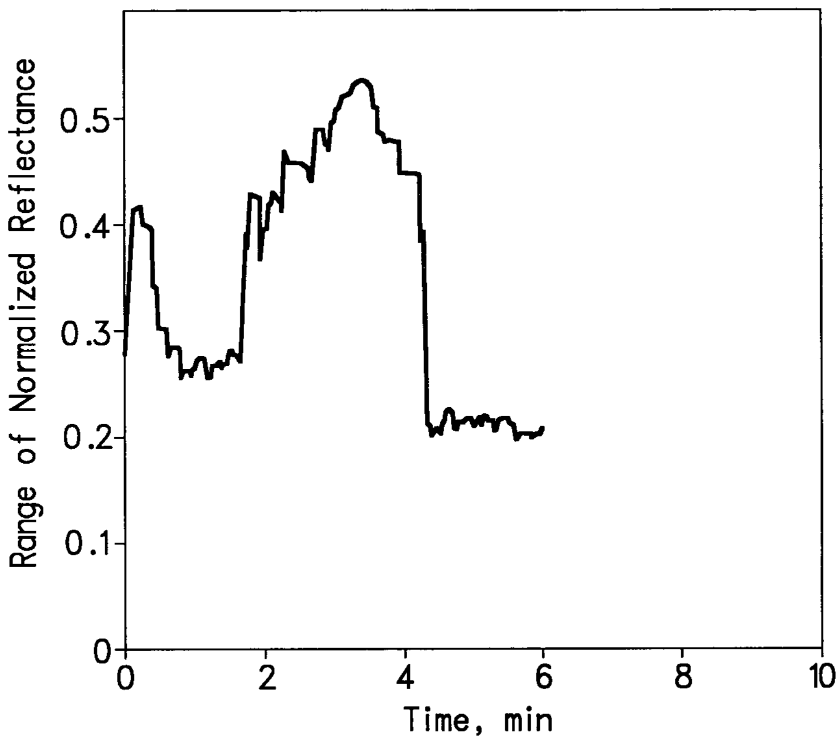
Results of the moving average versus time with estimated interval at 99.5% confidence interval.

FIG. 34



Results of in-situ measurements of the standard deviation to the mean reflectance (wafer-level).

FIG. 35



Results of the range of surface reflectance versus polishing time (wafer-level).

FIG. 36

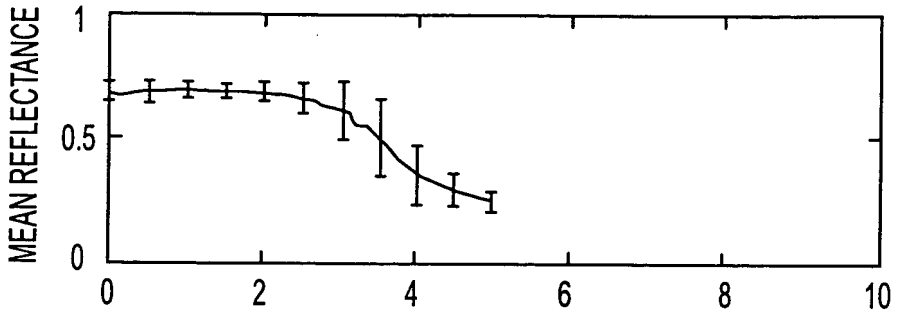


FIG. 37A

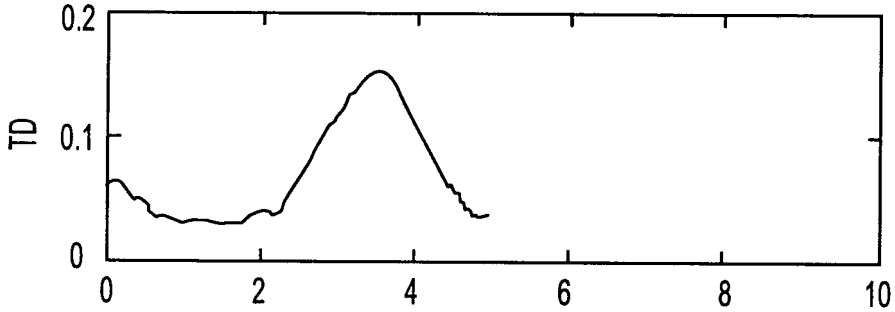


FIG. 37B

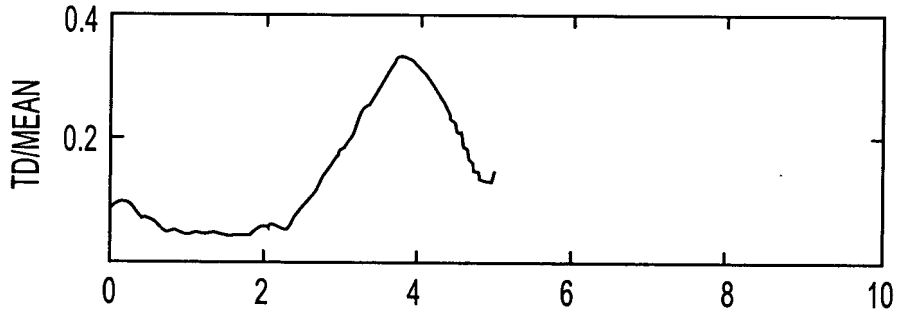


FIG. 37C

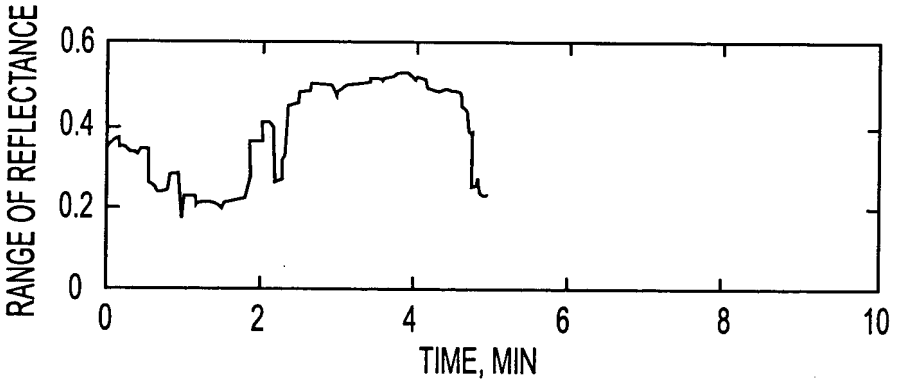


FIG. 37D